Claims

What we claim is:

1. A device comprising:

a nanostructured anodic alumina substrate, wherein said anodic alumina substrate comprises substantially parallel nanoscale pores; and

electrodes formed on one or both sides of the anodic alumina substrate and substantially perpendicular to the nanoscale pores.

2. The device of claim 1, wherein said device comprises one or more sensors, wherein when more than one sensor is present the device comprises a sensor array.

3. The device of claim 2, wherein said electrodes further comprise:

a first sensing electrode formed on the anodic alumina substrate and substantially perpendicular to the nanoscale pores.

4. The device of claim 3, wherein said sensor comprises:

a second sensing electrode formed on an opposite side of the anodic alumina substrate from the first sensing electrode.

5. The device of claim 3, wherein said first sensing electrode comprises platinum.

6. The device of claim 1, wherein said anodic alumina substrate comprises a sensing material inside the nanoscale pores, forming a sensing element.

7. The device of claim 6, wherein said sensing material is selected from the group consisting of metals, non-metals, oxides, salts, polymers, organic compounds, and inorganic compounds.

8. The device of claim 6, wherein said sensing material comprises titanium oxide.

9. The device of claim 6, wherein said sensing material comprises tin oxide.

10. The device of claim 6, wherein said sensing material comprises zinc oxide.

11. The device of claim 2, wherein at least one of said sensors further comprises: a microheater formed on said the anodic alumina substrate.

12. The device of claim 10, wherein said device further comprises:

an insulating layer formed between one of the sensing electrodes and microheater.

13. The device of claim 11, wherein at least one of said sensors comprises:

an adhesion promoting layer between the anodic alumina substrate and sensing electrodes or microheater to strengthen the bond between the substrate and the electrode or microheater.

14. The device of claim 13, wherein said adhesion-promoting layer comprises tantalum or titanium.

15. The device of claim 2, wherein at least one of said sensors comprises:

at least one contact pin coupled to the anodic alumina substrate; and

a support substrate coupled to the anodic alumina substrate through said at least one contact pin.

16. The device of claim 2, wherein at least one of said sensors comprises:

at least one contact pad coupled to the anodic alumina substrate; and

a flexible support substrate coupled to the anodic alumina substrate through said at least one contact pad.

17. The device of claim 2, wherein the anodic alumina substrate has a thickness of 0.1 μm to 500 μm.

18. The device of claim 2, wherein said nanoscale pores have a diameter of 1 nm to 500 nm.

19. The device of claim 2, wherein said nanoscale pores are substantially uniform in diameter.

20. The device of claim 6, wherein said sensing material comprises a layer having a thikness in the range of 0.1 nm to 500 nm in thickness.

21. The device of claim 2, wherein at least one of said sensors detects an analyte.

22. The device of claim 20, wherein said analyte is selected from the group consisting of chemical analytes and biological analytes.

23. The device of claim 20, wherein said analyte is selected from the group consisting of water vapor, oxygen, oxides of nitrogen, oxides of carbon, oxide of sulfur, hydrocarbons, VOCs, alcohols, and aldehydes.

24. The device of claim 20, wherein said analyte is selected from the group consisting of methane, ethanol, formaldehyde, carbon monoxide and hydrogen.

25. The device of claim 20, wherein said at least one sensor detects the analyte by measuring a property, said property selected from the group consisting of physical properties, chemical properties, electrical properties, magnetic properties, structural properties, thermal properties, optical properties, and any combination thereof.

26. The device of claim 2, wherein said at least one sensor detects an air quality property selected from the group consisting of temperature, pressure, relative humidity, and air flow rate.

27. A method of making a sensor comprising the steps of:

forming an anodic alumina film on an aluminum substrate, wherein said anodic alumina substrate comprises substantially parallel nanoscale pores;

micromachining the anodic alumina film to obtain sensor or sensor array substrates by a technique selected from the group consisting of anisotropic etching and localized anodization; and

forming a sensing and microheater electrodes on the anodic alumina substrate, wherein the said electrodes are substantially perpendicular to the nanoscale pores.

28. The method of claim 27, wherein the forming of the sensing and microheater electrodes on the anodic alumina substrate is done by a technique selected from the group consisting of vacuum thermal evaporation, DC plasma sputtering, RF plasma sputtering, chemical vapor deposition, electrochemical deposition, and screen printing.

29. The method of claim 27, said method comprising the step of:

depositing a sensing material in the nanoscale pores of the anodic alumina substrate.

30. The method of claim 29, wherein the depositing of the sensing material in the nanoscale pores is done by a technique selected from the group consisting of electrodeposition, sol-gel processes, solution impregnation, spin coating, spray coating, gas phase physical deposition and chemical vapor deposition.

31. The method of claim 30, where the depositing of sensing materials is controlled in-situ by monitoring the resistance of the sensing element during the process of deposition.

32. The method of claim 27, wherein said method comprises the step of:

forming an adhesion-promoting layer between the anodic alumina substrate and the first sensing electrode to strengthen the bond between the substrate and the electrode.

33. The method of claim 27, wherein said adhesion-promoting layer comprises tantalum or titanium.

34. A method of operation of sensor having a heater comprising of the following modes:

a passive mode, wherein heater power is turned off during the sensing;

a constant temperature mode, wherein the constant voltage, current or power is applied to a microheater during the sensing;

a temperature pulse mode; wherein a pulse of voltage, current or power is applied to the microheater during the sensing;

a temperature modulation mode, wherein a desired voltage, current or power waveform is applied to a microheater during the sensing; and

wherein a property of the sensing element is monitored to obtain sensor signal during the sensing.

35. The method of claim 34 further comprising a temperature pulse mode to induce desorption of the water molecules from the sensor in a "heater on" half-cycle, and adsorption of water molecule in a "heater off" half cycle.

36. The method of claim 34, where temperature modulation is performed by modulating microheater voltage at a rate of up to 20 V per second.

37. The method of claim 34, where temperature pulse or temperature modulation is used to regenerate a sensor after contamination, wetting or icing.